The Lunar Eclipse of July 12 1870.

Greenwich Mean Time.	Selenographic longitude and latitude of the most northerly, the middle and the most southerly point of the geometrical outline of the total shadow, on the moon's surface.						Geographic long. (E or W of Greenw.) and latit. of the corresponding points of the curve on the earth's surface, along which the last rays of the sun disappear or the first rays reappear.					
8^h45^m7			−84°3	−1°4					43°1W	8°2 S		
48	−84°3	+18°1	61,4	1,1	−84°3	−20°6	41°1W	1°7 S	43,7	8,3	46°5W	14°9 S
52	84,4	31,5	46,1	0,8	84,4	33,6	40,5	2,2 N	44,8	8,5	49,4	19,3
8 56	84,4	41,5	35,0	0,5	84,4	43,1	40,5	4,7	45,9	8,8	51,8	22,2
9 0	84,4	50,2	25,5	0,3	84,4	51,2	40,7	6,6	47,0	9,0	53,9	24,5
4	84,5	58,2	16,9	−0,1	84,5	58,6	41,2	7,9	48,1	9,3	55,8	26,4
8	−84,5	+65,9	− 8,8	0,0	−84,5	−65,7	41,8	8,9 N	49,3	9,6 S	57,6	27,9 S
12	84,5	73,5	− 1,0	+0,1	84,5	72,5	42,5	9,5	50,4	9,9	59,2	29,1
16	84,6	81,1	+ 6,7	0,0	84,6	79,3	43,4	9,8	51,5	10,3	60,7	30,1
20	−84,6	88,9	14,4	−0,2	−84,6	86,3	44,5	9,6	52,7	10,7	62,1	30,8
24	+95,4	82,8	22,2	0,5	+95,4	86,4	45,7	9,1	53,9	11,2	63,3	31,1
28	+95,3	+74,0	+30,3	−1,0	+95,3	−78,6	47,1	8,1 N	55,1	11,6 S	64,3	31,1 S
32	95,3	64,2	39,3	1,6	95,3	70,0	48,8	6,5	56,3	12,2	65,0	30,7
36	95,3	52,9	48,7	2,5	95,3	60,1	50,8	4,0	57,6	12,8	65,4	29,5
40	95,2	38,8	60,2	3,6	95,2	47,6	53,3	0,2 N	58,9	13,6	65,2	27,2
44	+95,2	+16,5	77,2	5,0	+95,2	−28,1	57,1W	6,7 S	60,3	14,4	63,7W	22,1 S
9 45,5			+95,2	−5,6					60,8W	14,7 S		
11^h22^m8			−85°6	−20°1					104°1 E	9°4 S		
24	−85°6	+ 0°6	68,9	19,0	−85°6	−39°9	101°3 E	2°2 S	103,7	9,1	106°6 E	16°0 S
28	85,7	23,1	50,4	15,6	85,7	60,8	96,3	6,9 N	102,4	8,4	108,2	21,8
32	85,7	37,5	38,6	12,5	85,7	73,6	94,4	9,1	101,1	7,5	108,3	24,1
36	85,7	48,9	29,0	9,7	−85,7	83,7	92,3	11,7	99,8	6,9	107,9	25,3
40	85,8	58,8	20,5	7,2	+94,2	87,6	90,6	13,4	98,6	6,3	107,2	25,9
44	−85,8	+67,7	−16,6	− 4,8	+94,2	−79,8	89,1	14,4 N	97,4	5,8 S	106,2	25,9 S
48	85,8	76,0	− 5,1	2,6	94,2	72,5	87,9	15,0	96,2	5,4	105,1	25,6
52	−85,9	83,9	+ 2,3	− 0,5	94,1	65,5	86,8	15,1	95,0	5,0	103,7	24,9
11 56	+94,1	88,5	9,7	+ 1,5	94,1	58,6	85,9	14,9	93,9	4,7	102,3	24,1
12 0	94,1	80,9	17,3	3,4	94,1	51,8	85,2	14,3	92,8	4,3	100,7	22,8
4	+94,0	+73,2	+25,2	+ 5,2	+94,0	−44,8	84,6	13,4 N	91,6	4,0 S	99,0	21,2 S
8	94,0	65,3	33,6	7,0	94,0	37,4	84,2	12,1	90,5	3,7	97,1	19,4
12	94,0	56,7	42,9	8,7	94,0	29,3	83,9	10,3	89,4	3,4	95,1	17,1
16	93,9	46,8	54,0	10,4	93,9	20,0	83,9	7,8	88,3	3,2	92,8	14,2
20	+93,9	+33,8	68,9	12,0	+93,9	− 7,4	84,4 E	4,1 N	87,2	3,0	90,1 E	14,0 S
12 22,6			+93,9	+13,0					86,5 E	2,8 S		

Though the indefinite character of the outline of the earth's shadow on the moon's surface may render observations of the passing of lunar spots into and out of the shadow considerably uncertain, it is very desirable that such observations should not be neglected, so that the apparent extent of the shadow and the degree of its uncertainty may be properly determined by strict calculation, what, so far as I am aware, has never yet been done. For this purpose it is required, that observers should not only note the times, when selected spots of well determined selenographic position are in contact with the unquestionably full shadow, but also the times, when they are at or near the questionable boundary of the dark zone surrounding it, the extent of which is to be ascertained.

The place of a lunar spot (λ, β) relative to the axis of the shadow may be found for any time during the eclipse by means of the equations

$$\Delta'' \sin S'' \sin (P'' - C_0) = X + k \cos\beta \sin(\Lambda - \lambda)$$
$$\Delta'' \sin S'' \cos (P'' - C_0) = Y - k \cos\beta \cos(\Lambda - \lambda) \sin B + k \sin\beta \cos B$$
$$\Delta'' \cos S'' = Z - k \cos\beta \cos(\Lambda - \lambda) \cos B - k \sin\beta \sin B,$$

which give the geocentric angle of position P'' and angular distance S'' of the spot in reference to the axis of the shadow, and also its linear distance Δ'' from the center of the earth. The values of X, Y, Z, A, B, C_0*) are supplied for every hour of the eclipse by the following table:

Greenw. M. T.	X		Y		Z	
8h	—1,4242		+0,0770		58,666	
		+,5493		—,0695		+,035
9	—0,8749	,5492	+ ,0075	,0695	,701	,031
10	—0,3257	,5493	— ,0620	,0694	,732	,025
11	+0,2236	,5492	— ,1314	,0695	,757	,020
12	+0,7728		— ,2009		,777	
		+,5492		—,0694		+,016
13	+1,3220		—0,2703		58,793	

Greenw. M. T.	A		B	C
8h	+6° 5′ 4⅓		+0°1′ 66	—10°3′ 08
		—30′ 56		
9	5 34,92	30,56	1,72	4,03
10	5 4,36	30,56	1,78	4,98
11	4 33,80	30,56	1,84	5,93
12	4 3,24	30,56	1,90	6,88
		—30,55		
13	+3 32,69		+0 1,96	—10 7,83

k is the distance of the spot from the moon's center, the unit of the linear distances being the semediameter of the earth's equator.

The data for these computations have been taken from the Nautical Almanac, except the values of Ω and l_0, the longitude of the ascending node of the moon's orbit and the moon's mean longitude, which have been derived from the Berliner Jahrbuch. The assumed inclination i of the lunar equator to the ecliptic is *Wichmann*'s 1°32′9″.

To determine the libration: let α_0 be the moon's mean rightascension, I the inclination of the plane of the moon's equator to the plane of the earth's equator and N its ascending node (all referred to the true equator and the true equinox). If then α', δ' are the apparent rightascension and declination of the moon's center for the place of observing, the libration in longitude and latitude or the selenographic longitude λ_0 and latitude β_0 of the apparent center and also the angle of position C of the circle of selenographic latitude at the center may be found by means of the equations

$$tg\,\psi = tg\,J\,sin(\alpha'-N)$$
$$tg\,C = -\,tg\,J\,cos(\alpha'-N)\cdot\frac{cos\,\psi}{cos(\psi-\delta')}$$
$$tg\,\beta_0 = tg(\psi-\delta')\,cos\,C$$
$$tg\,\chi = tg\,\tfrac{1}{2}\,J\,sin(\alpha'-N)$$
$$sin(\lambda_0+\alpha_0-\alpha') = \frac{sin(\chi-\delta')}{cos\,\chi}\cdot sin\,C.$$

For the evening of the eclipse we have

8h	$\alpha_0 = 283°47'40''9$,	$J = 24°0'2''4$,	$N = -3°34'7''4$
12	285 59 26,1	2,8	8,1

Hence the moon's libration for the center of the earth:

Greenw. M. T.	λ_0		β_0		C	
8h	+4°42′ 04		—0° 2′ 86		— 9°29′ 50	
		+1′ 64		+4′ 14		—14′ 13
9	43,68	1,62	+0 1,28	4,13	9 43,63	—14,05
10	45,30	1,59	5,41	4,12	9 57,68	—13,96
11	46,89	1,56	9,53	4,12	10 11,64	—13,89
12	48,45		13,65		10 25,53	
		+1,52		+4,11		—13,80
13	+4 49,97		+0 17,76		—10 39,33	

Of stars, which are to be occulted during the totality of the eclipse, I can find only one, the position of which has been determined in the meridian:

Arg. Z. 311, № 6. 9m App. place 19h28m43s42, —23°5′52″5.

Elements for computing the occultation:

$T = 10^h30^m$ Gr. M. T. $p = -0,2557$, $p' = +0,5931$
$k = -24°4'2$ $q = +1,1015$, $q' = +0,0354$.

*) X, Y, Z are the rectangular coordinates of the moon's center refferred to the earth's center, the axis of Z being the axis of the shadow (or directed to the heliocentric place of the earth, say O), the axis of X being perpendicular upon it in the plane of the circle of selenographic latitude, the axis of X being perpendicular upon both. $\Lambda + 180°$ and $-B$ are the selenographic longitude and latitude of O and C_0 the angle of position of the circle of selenographic latitude at O.

Ferndene, Gateshead. *A. Marth.*